

AS  
Contd

35. A photovoltaic module having an array of electrically interconnected photovoltaic cells encapsulated between a transparent front support sheet and a back sheet by a light-transmitting ionomer, said array of photovoltaic cells including a plurality of electrical conductors connected to said photovoltaic cells by solder, with at least some of the soldered connections being characterized by an acid flux residue, the improvement wherein said light-transmitting ionomer is a zinc ionomer that has the properties set forth in Tables I and II of the preceding specification and absorbs no more than about 0.3 wt % water.

#### REMARKS

Submitted separately with this amendment is a petition for extending the time for response from 16 August 2002 to 16 October 2002.

Extensive changes have been made to specification to comply with the suggestions set forth on page 2 of the Official Action. The Appendix attached hereto identifies the specific changes by brackets and underlining as prescribed by the rules of practice.

With the exception of alleged informality 1(a) listed on page 2 of the Official Action of 16 May 2002, the changes made to the specification are in compliance with the suggestions made on page 2 of the Official Action. The term "Chimasorb 944" remains unchanged since that is the name used by the manufacturer for its light stabilizers. It is believed that these changes correct all of the outstanding errors in the specification.

As a result of this amendment, claims 23-35 are now in the application. The deletion of claims 1-22 is not to be construed as an abandonment of any of the inventive features of Applicant's invention. Rather new claims 23-35 were submitted to simplify this response to the outstanding Official Action and expedite prosecution of the application.

Applicant respectfully requests reconsideration on the basis of the new claims submitted herewith. In this context, the rejection of the previous claims under 35 USC 112, second paragraph, has been duly noted. The new claims

have been drafted to avoid the specific language objected to by the Examiner. Applicant believes that these new claims are free of indefiniteness and fully comply with Section 112.

The previous claims were rejected under 35 USC 102 as being anticipated by Hanoka 5,733,382 (U.S. '382) or under 35 USC 103(a) as being unpatentable over Hanoka U.S. '382 alone or in view of one or more of the following: Hanoka U.S. '553, Hanoka U.S. '042, Hanoka U.S. '116 and French U.S. Patent 4,287,382.

Hanoka U.S. '382 has been duly considered. Applicant submits that there is nothing in the Hanoka '382 patent that indicates that the SURLYN 1702 ionomer is functionally equivalent to the SURLYN 1705-1 ionomer in the sense that it will permit the manufacture of photovoltaic modules having the exceptional stress test results describe on pages 14 and 15 of Applicant's specification. To the contrary, in column 9, lines 20-40, Hanoka indicates that the "suitable temperature" for forming the laminated module with SURLYN 1702 is about 170-180°C. In column 10, lines 39-42, the laminating temperature is identified as approximately 175°C. Nor is there anything in Hanoka '382 to suggest that the lamination procedure may occur at a lower temperature.

The question of laminating temperature is important because of the fact that the whole purpose of Applicant's invention is to avoid degradation of the ionomer. Applicant's invention involves discovery of the fact that sodium based ionomers are reactive to acid and that the soldered connections for the conductors used to interconnect photovoltaic cells often have acidic flux residues. The higher the temperature to which an ionomer is heated, the greater the likelihood of thermal degradation of the ionomer. As noted on page 6, third paragraph, use of a zinc based ionomer as disclosed in the present application permits the laminating process to be conducted under moderate level without any thermal degradation of the ionomer.

In the present invention, Applicant has determined that: (1) modules made with sodium ionomers tend to fail due to reaction with acidic solder flux residues at

the points where the interconnecting conductors are soldered to the contacts of the individual photovoltaic cells, and (2) zinc ionomers offer more resistance to reaction with acidic flux residues than sodium ionomers. More specifically, Applicant has discovered that a particular form of zinc ionomer permits the laminating process to be conducted at a temperature that is sufficiently low as to substantially eliminate any likelihood of degradation due to reaction with acid solder flux residues, while simultaneously assuring complete encapsulation of the solar cells with a high tack strength adherence of the encapsulant to the front and back protective sheets of the module. Accordingly, Applicant submits that Hanoka U.S. '382 does not anticipate Applicant's invention or render it unpatentable under 35 USC 103(a) as being obvious.

On page 9 of the Official Action, the Examiner has stated that it would be obvious to have modified the apparatus of Hanoka U.S. '382 to use an acidic flux to solder the conductors onto the photovoltaic cells because it is common practice to use acidic flux when making flux connections. However, what is not obvious to a person having ordinary skill in the art is the fact that acidic flux reactions with ionomers can shorten the useful life and reduce performance of photovoltaic modules containing such ionomers as encapsulants, and also that such reactions can be substantially avoided or reduced to a negligible level by using a particular zinc ionomer as the encapsulant.

In paragraph 10 of the Official Action, the Examiner has contended that DuPont's SURLYN 1705-1 is similar to SURLYN 1702, since both are zinc ionomers, and that it would have been obvious to one having ordinary skill in the art to have modified the apparatus of Hanoka U.S. '382 to use the SURLYN 1705-1 instead of the SURLYN 1702, since they would be expected to function in the same manner. However, as pointed out above, there is no basis for the Examiner's conclusion that the two materials are so similar as to be expected to function in the same manner when used as an encapsulant in a photovoltaic module. In fact, Applicant's specification suggests otherwise.

In this connection the Examiner's attention is drawn to page 3, second paragraph of the instant application, wherein Hanoka's U. S. Patent No. 5,478,402 (Hanoka U.S. '402) is described as disclosing two sodium based ionomers, SURLYN 1601 and SURLYN 1707. Those materials are indicated on page 4 of Applicant's specification as requiring a lamination temperature of about 170-180°C, essentially the same temperature as is required by the SURLYN 1601 and SURLYN 1702 products listed in Hanoka U.S. '382. Applicant submits that the fact that the product number is a "1700" series number is no indication that the materials will behave the same, since the SURLYN 1702 is identified as a zinc ionomer in Hanoka U.S. '382, while the SURLYN 1707 is identified in Applicant's specification as a sodium based ionomer. In any event, the Hanoka U.S. '382 has no appreciation of the fact that the length of the useful life of a photovoltaic module made with an ionomer encapsulant is determined in part by the presence of acid flux residues in the case where the several photovoltaic cells are connected by soldered conductors.

The Hanoka U.S. '042 patent adds nothing to the disclosure of the Hanoka U.S. '382 patent with respect to the use of ionomers, but rather has been cited merely as indicating that the photovoltaic modules may comprise thin-filmed cells and either CIGS or cadmium telluride cells.

Hanoka U.S. '116 has to do with providing a different form of encapsulant, the different form of encapsulant comprising several layers of different materials attached to one another. It shows no appreciation of the problem that is solved by Applicant's invention and, therefore, it adds nothing to the disclosure of Hanoka U.S. '382.

Hanoka U.S. '553 discloses the use of an ionomer as an encapsulant. Like Hanoka U. S. '402, it discloses a sodium ionomer marketed by DuPont under the name SURLYN 1601 and another ionomer product known as SURLYN 1707, both of which have been mentioned hereinabove. In column 8, of Hanoka U.S. '553, it is indicated that the temperature for lamination must be about 170°C in order to

achieve proper lamination. It does not suggest that a lower lamination temperature can be used to manufacture modules with an ionomer encapsulant

French U.S. Patent 4,287,382 has been cited as disclosing the use of a scrim layer between the encapsulating sheets in order to facilitate removal of air. Applicant is not claiming that the use of a scrim material is novel per se. the French patent adds nothing of value with respect to selecting the type of ionomer to use in order to achieve solar cells with extended useful life.

The advantage of Applicant's invention is made evident by the fact that modules made according to the invention have passed stress tests of 1000 hours at 85% relative humidity and 85°C damp heat, as well as 20 cycles of temperature humidity cycling with the temperature ranging from 85°C to -40°. In addition to showing no decreased electrical performance after such tests, the tested modules fully satisfy the safety criteria of the wet and dry high voltage withstand tests at 3600 volts as well as the insulation resistance criteria measured at 500 volts. These results have not been achieved previously with other ionomer encapsulants.

The new claims presented with this amendment are designed to distinguish from the prior art of record. drawn specifically to the use of zinc ionomer encapsulants that are capable of providing the specific results that Applicant has achieved. Applicant's new product claims are limited to the specific ionomer that provides the exceptional results described in the application. Applicant's new method claims are all limited as to the temperature at which the lamination is conducted, as well as including specific limitations as to the ionomer encapsulant.

In view of the foregoing remarks, it is respectfully submitted that the claims now in the application define a patentable invention and should be allowed.

Prompt and favorable reconsideration is solicited.

Respectfully submitted,

 10/15/02

Nicholas A. Pandiscio  
Reg. No. 17,293  
Pandiscio & Pandiscio  
470 Totten Pond Road  
Waltham, MA 02451-1914  
Tel. (781) 290-0060  
Attorneys for Applicant

### Mailing Certificate

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, sufficient postage prepaid, in an envelope addressed to the Assistant Commissioner For Patents, Washington, D.C. 20231 on the date indicated below:

**15 October 2002**

(date of deposit)

**NICHOLAS A. PANDISCIO**

(name of attorney)

  
(signature)

APPENDIXIN THE SPECIFICATION:

Page 8 -- please replace the paragraph commencing in line 5 with the following new paragraph:

The present invention overcomes the problem of flux-induced ionomer degradation by using a zinc-based ionomer as the encapsulant. It has been determined that zinc-based ionomers exist that are transparent, stable and capable of bonding adjacent components of a solar cell module. Such zinc-based ionomers are exemplified by two DuPont products identified as SURLYN 1705-1 and SURLYN 1706. These polymers have excellent optical properties and high hot tack strength. The exact chemical composition of these materials is not known, but they are believed to be produced by adding a salt containing zinc cations to a copolymer of ethylene-methacrylic acid, or to a copolymer of ethylene-acrylic acid, and subjecting that composition to acid neutralization, resulting in the formation of ion clusters within the resulting polymer matrix. The SURLYN 1705-1 composition is preferred since the SURLYN 1706 is more viscous and has a somewhat higher melting temperature. The properties of the SURLYN 1705-1 product as a resin and also in sheet form are set forth in Tables I and II respectively:

Page 10 -- please replace the first paragraph with the following new paragraph:

In accordance with the preferred embodiment of the invention, additives for mitigating UV-induced [photooxidation] photo-oxidation are incorporated in the zinc ionomer. Preferably the additives are added in amounts ranging from about 0.3 to about 1.0 wt. % and consist of a UV light absorber in the form of Tinuvin 328, a product manufactured by Geigy Chemical Corporation of Ardsley, New York, which is believed to be 2-(2H-benzotriazol-2-yl)-4,6-ditertpentylphenol, and a UV stabilizer in the form of Chimasorb 944, also a product manufactured by Geigy

Chemical Corporation, which is identified by the manufacturer as a sterically hindered amine light stabilizer (commonly identified as HALS).

Page 10 -- replace the second paragraph with the following new paragraph:

Test specimens, each comprising two 0.010 inch thick layers of Surlyn 1705-1, modified with 0.3 wt % Tinuvin 328 and about 0.3 wt. % Chimisorb 944, disposed between and bonded to two sheets of glass, showed improved radiation transmission in the 400 to 800 nm wavelength region and, more importantly, the specimens resisted [photooxidation] photo-oxidation and maintained their high transmission properties in that wavelength region without discernible color alteration after prolonged and intense radiation stress exposure. More specifically, the test specimens were made using two different glasses. In one case, the front and back glass sheets were Solatex II glass (a tempered solar grade glass). In the other case, the two glass sheets were a borosilicate glass. Figs. 1 and 2 illustrate the radiation transmission curves for test specimens made with Solatex II glass and borosilicate glass respectively. It is clear that in both cases, the transmission property for each specimen after 8 months exposure to the test condition is virtually the same as what it was immediately after fabrication and before testing.

Page 13 -- please replace the first paragraph of the example (lines 5-25) with the following paragraph:

#### Example

A sheet of tempered solar grade CeO-free glass, having a thickness of 3/16 inch, is placed face down on a supporting surface. Two 0.010 inch thick corona-treated sheets of Surlyn 1705-1 zinc based ionomer, modified with 0.30% Chimisorb 944 and 0.30% Tinuvin 328, are placed over the top surface of the glass sheet. An array of inter-connected silicon solar cells made from rectangular polycrystalline EFG-grown wafers is placed on top of the two Surlyn 1705-1 sheets, with the front contacts of the cells facing the glass sheet. The conductors



interconnecting the solar cells have been soldered to the front and back contacts of the cells using a tin/silver solder as prescribed by Gonsiorawski in U.S. Patent No. 5,074,920, and an acidic carboxylate flux. The ionomer sheets are oriented so that the corona-treated surface of one sheet engages the glass sheet, and the corona-treated surface of the second sheet faces the array of solar cells. A scrim layer with a thickness of about 0.005 inch is placed over the array of solar cells in contact with the back contacts of the cells and the interconnecting conductors. Then another 0.010 inch thick sheet of the same modified Surlyn 1705-1 zinc ionomer is placed over the scrim with its corona-treated surface facing away from the scrim, and that ionomer sheet is covered by a back sheet of Tedlar. The Tedlar has a thickness of approximately 0.0015 inch. The resulting sandwich-like assembly is placed in a vacuum press and laminated.

Pages 14 and 15 -- please replace the last paragraph on page 14 and the first paragraph on page 15 with the following new paragraph:

Panels incorporating silicon solar cell modules made according to the present invention, e.g., as set forth in the foregoing example, have passed stress tests of 1000 hours of 85% [RH/85% °C] RH/85° C damp heat as well as the humidity-freeze cycling (85/85 to 0/-40) for 20 cycles without decreased electrical photovoltaic performance while fully satisfying the safety criteria of the wet and dry high voltage withstand tests at 3600 volts as well as the insulation resistance criteria measured at 500 volts. This success using a Tedlar substrate is because the zinc ionomer encapsulant has a low water solubility which when coupled with the encapsulant's strong adherence capability avoids premature voltage breakdown and significant current conduction paths from cells to ground. By way of comparison, the zinc Surlyn 1705-1 material has a water absorption of 0.3 wt. % in comparison to the sodium Surlyn 1601 and EVA which have water [absorption s] absorptions of 3.0 wt. % and 0.7 wt. % respectively. Moreover, the condition of the physical structure of the solar modules is virtually unchanged from its pre-stress state and that includes the absence of (a) liquid water droplets that

cause other encapsulant systems like EVA to become hazy and (b) the development of blisters beneath the Tedlar substrate resulting from hydrolytic attack at the underlying encapsulant interface.

Replace the paragraph on page 16 and ending on page 17, third line, with the following new paragraph:

Obviously it is possible to modify the components of the solar modules and the method of laminating the components without departing from the scope of the invention. Although modules made according to the invention using a non-CeO doped glass as the front panel show advantages over the prior art with respect to the ionomer encapsulant resisting [photooxidation] photo-oxidation and maintaining solar radiation transmission in the 400 to 800 nm wavelength range and are preferred due to the reduced cost of such glass, the invention may be practiced using a CeO-doped solar glass front panel where cost is to a controlling factor. Also the glass front panel may be replaced by a sheet of a transparent plastic material, e.g., a polycarbonate or an acrylic polymer, while the backskin or rear panel may be made of glass or some other transparent, translucent or opaque material, e.g., a multi-composition laminate. It is also within the scope of the invention to vary one or more of the parameters of the laminating process, including but not limited to: (a) the rate at which the components are heated up to the desired maximum temperature, (b) the rate at which the compressive pressure exerted on the modules is increased to the desired maximum level, and (c) the length of time that the components are subjected to the maximum temperature and pressure conditions. The number and thickness of the zinc ionomer sheets used in making the module also may be varied. The Surlyn 1705-1 zinc ionomer may be replaced by the SURLYN 1706 zinc ionomer which also has a high radiant energy transmissibility. However, use of the SURLYN 1706 zinc ionomer is not preferred since it requires that the lamination proceed at a temperature in the range of about 160°C to about 185°C. Other zinc ionomers resistant to acids and having a comparable low moisture absorption also may be used so long as they

meet the following requirements: acceptable light transmission, adequate bonding adherence, high melt flow, and resistance to [photooxidation]

photo-oxidation. It is to be understood also that the other UV absorbers and stabilizers may be found to be acceptable substitutes for the Tinuvin 328[9] and Chimasorb 944.

Pages 17 and 18 -- please replace the second paragraph on page 17 and the first paragraph on page 18, with the following new paragraph:

Also the invention may be used in the manufacture of modules comprising different forms of solar cells known to persons skilled in the art. Silicon solar cells of the type contemplated herein and also in U.S. Patents Nos. 5,478,402 and 5,476,553, supra, comprise silicon wafers with a p-n junction formed by doping, as disclosed, for example, in U.S. Patent No. 4,751,191, issued 6/14/88 to R. C. Gonsiorawski et al, and U.S. Patent No. 5,178,685, issued 1/12/93 to J. T. Borenstein et al. The invention may be used also in modules that comprise other cells formed independently of one another but interconnected by soldered conductors, notably cells comprising a semiconductor substrate such as germanium or gallium arsenide onto which one or more layers of another crystalline material are epitaxially grown to form one or more junctions, as disclosed, for example, in U.S. Patents No. 5,944,913, issued 8/31/99 to H. Q. Hou et al. and U.S. Patent No. 6,252,287, issued 6/26/2001 to S. R. Kurtz et al. The invention also may be incorporated in modules that comprise so-called thin film solar cells. Typically such solar cell modules are produced by depositing several thin film layers on a substrate such as glass, with the layers being patterned so as to form a plurality of individual cells that are electrically interconnected to provide a suitable voltage output. Depending on the sequence in which the multi-layer deposition is carried out, the glass substrate may function as the back surface or as a front window for the module. By way of example, thin film solar cells are disclosed in U.S. Patents Nos. 5,512,107, issued 4/30/96 to R. van der Berg; 5,948,176, issued [9/7199] 9/7/99 to K. V. Ramanathan et al.;

5,994,163, issued 11/30/99 to M. Bodegård et al.; 6,040,521, issued 3/21/2000 to K. Kushiya et al; 6,137,048, issued 10/24/2000 to X. Wu; and 6,258,620, issued 7/10/2001 to D. L. Morel et al.

ase applns. #2  
ase08cip.ama